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## TECHNOLOGICAL SPECIFICS OF PRODUCTION OF OPTICAL ELEMENTS FOR MINI-KINESCOPIES

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An automated line is developed for the production of optical elements (screens, cones) for kinescopes. New molding equipment is designed, and technological parameters for the production of screens and cones 12 cm in the diagonal are developed.

In view of the rapidly growing construction of modern supermarkets, banks, offices, and residential housing and the improvement of security and communication systems and navigation systems in the car and aircraft industries, the supply of portable video equipment for these facilities becomes very important.

Such video equipment allows for real-time monitoring of numerous objects inside and outside buildings, which significantly increases the efficiency of security measures. The use of such equipment in automobile navigating systems inside cars provides for substantial saving in time and, accordingly, in energy consumption, due to the optimization of the routes. Microvideo devices are becoming common household items and are increasingly used in videotelephones, portable TV, and displays.

The main elements determining the quality of image in video systems are the optical glass elements of the picture tube (the screen and the cone). Manufacturing optical elements for picture tubes, especially for mini-kinescopes, is a high-technology sector of glass production. This is due to rigorous technical requirements imposed on these elements (Table 1).

The virtual absence of bubbles in the article, rigorous requirements with respect to other glass defects, small thickness of articles, and a high degree of homogeneity required of screen frosting, all this constituted a difficult engineering problem. Furthermore, there were no available automated technologies for the production of mini-kinescopes in Russia and the CIS countries. Such articles used to be manufactured manually.

In order to produce screens and cones for cathode-ray tubes that could be competitive

on the world market, Tekhnologiya Research and Production Association developed an automated production line which consists of:

- a regenerative glass-melting tank furnace with a horse-shoe direction of flame;
- an automatic glass melt collector ROBOT-IV with a shear;
- an automated press CRK-12-1000-N;
- a device for removing articles from the mold (a rear-ranger);
- a belt conveyor and an annealing furnace;
- a section for cutting caps, melting in anodes, quality control, and packaging.

Various technological factors influence the production of high-quality glass articles: the temperature of the produced glass melt, the weight of molded articles, the molding pressure, the temperature of the punch, the ring, and the matrix, the duration of fixation (molding) of an articles, the ring pressure, the molding rate, the consumption rate of air supplied for cooling of articles and molds.

The determining factors are the thermal parameters of the molding process, i.e., the temperature of the glass melt and the mold. Low temperatures of glass melt and the mold result in massive formation of notches, cracks, and creases. The resulting articles are thick-walled. However, excessively high temperatures also cause the formation of notches, cracks, and indents. The glass may stick to the mold surface.

TABLE 1

Product	Controlled parameters			
	bubble, mm	frosting homogeneity, Ra	spalling, dents, adhesion, crumbling, notches, creases, cracks	product thickness, mm
Screen 12LM	1 piece up to 0.25	0.4 – 0.6	Not admissible	3.0 – 3.5
Cone 12LM	1 piece up to 1.0	–	The same	1.8 – 2.3

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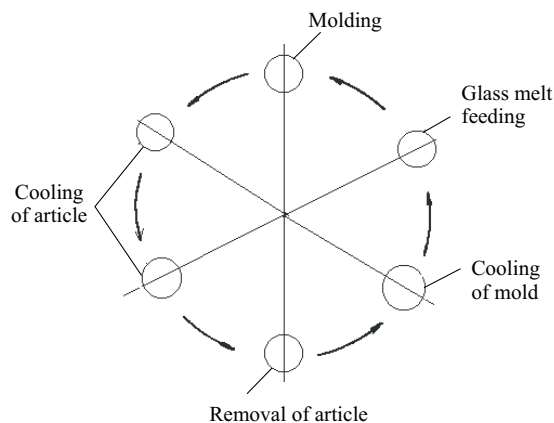


Fig. 1. Molding process cyclogram.

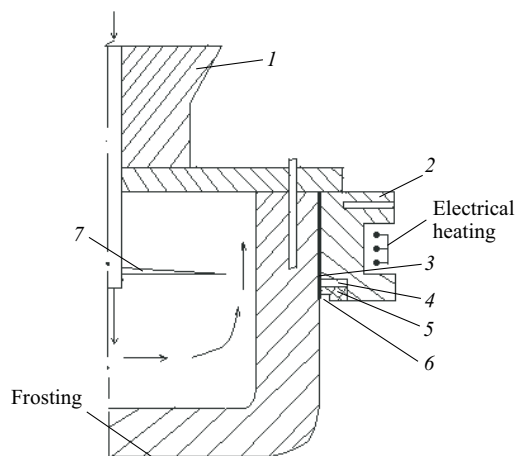


Fig. 2. Main design specifics of the punch and the ring for screen production: 1) punch; 2) ring; 3) wear-resistant coating; 4) groove; 5) insert; 6) lock; 7) distributor.

The molding pressure, the ring pressure, and the weight of the glass melt portion collected to mold an article determined the geometrical size of the product. The molding duration also determines the geometry of the product and influences such defects as dents, notches, and cracks.

The molding rate has a substantial effect on the thermal conditions of molds and should be as high as possible for the sake of economic efficiency. The forced air cooling of molded products and molds should be optimum as well, since the rate of air consumption affects the thermal conditions of molding equipment and the product quality.

Thus, it was necessary to correlate and coordinate more than ten technological parameters in order to make thin-walled high-quality articles, while ensuring a high efficiency of the process. In the beginning, the technological parameters were tested on six matrices; however, low temperature modes were used, and subsequently only three matrices were used in testing. The molding process cyclogram is shown in Fig. 1.

The thermal conditions of the molding equipment are affected not only by the technological process parameters, but also by design specifics of the mold rigging and the material of which the rigging is made. Therefore, in the course of testing the molding technology, the designs of punches, rings, and molding matrices for screens and cones had to be adjusted as well.

The mold rigging should have a long service life under elevated temperatures and high frequency of thermal cycles, and should withstand substantial temperature differences, which are required for plastic deformation of glass melt in molding. For this purpose, new designs of mold rigging for automated production of mini-screens (OTG 3015.01 SB) and mini-cones (OTG 3016.01 SB) were developed and brought to the stage of the optimum industrial prototype.

The principal design specifics of the punch and the ring for screen molding are shown in Fig. 2. The punch was made of heat-resistant steel 40Kh13. For uniform chilling of the punch, an umbrella-shaped distributor of water-air mixture was installed in the inner cavity of the punch. The distributor first directed the cooling agent to the high-temperature zone of the punch, i.e., its bottom part, and the reverse flow of water-air mixture was directed along the side walls.

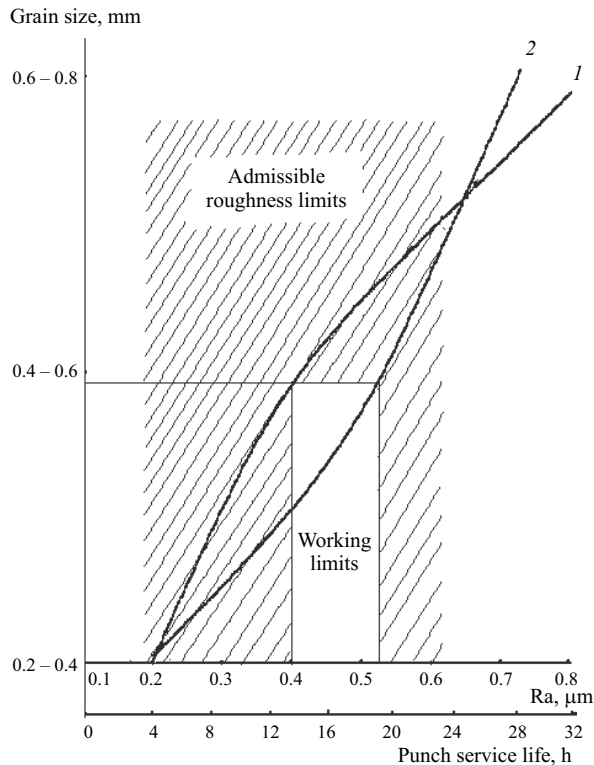
A new method for hardening the metal work surface, namely, the method of electric spark diffusion, was used to increase the wear resistance and the service life of the rigging. This method consists of periodic development of the breakdown voltage (spark) between the electrode (the treating material) and the treated material (the punch, the ring). In this case the electrode material is deposited in a thin layer (0.02 mm) on the surface of the treated article. A UR-121 desktop set for coating deposition was acquired.

Various materials were tested as protection of the work surface of punches. They were: carbide-tungsten alloys VK, titanium, tungsten, and molybdenum. The best results in wear resistance under high temperatures were obtained with molybdenum coating.

An important engineering requirement imposed on screens is uniform frosting of the work surface, which later is coated with luminophore. The homogeneity of the screen frosting depends on the roughness of the punch surface, and the latter, in turn, is determined by the fraction (grain diameter) of the treating material. Therefore, it was necessary to identify the optimum relationship between the fraction of the treating material (quartz sand was taken in this capacity), the degree of roughness of the article surface, its homogeneity, and the service life of the punch.

The experiments included treatment of the work surface of punches on a sand-blasting set using quartz sand of various fractions. Next, screens were manufactured, and the roughness of their working surfaces was measured.

The sand fractions were selected using sieves, and the roughness was measured on a profilograph. Figure 3 represents the identified dependences. It was found that the optimum sand fraction is 0.4 – 0.6 mm; in that case, the rough-

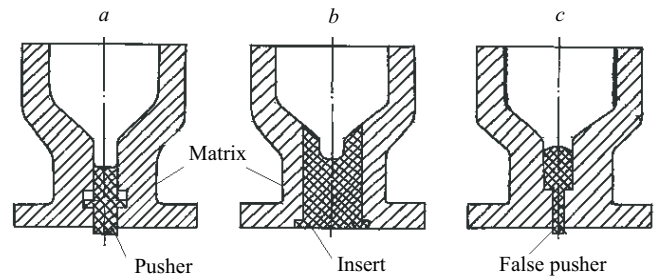


**Fig. 3.** Dependence of the roughness of the article surface (1) and the punch service life (2) on the silica fraction.

ness of the article surface is  $Ra = 0.35 - 0.65$ , and the service life of the punch before repairs varies from 10 to 20 h.

The ring, which largely determines the geometrical shape of the upper edge of the articles and the presence of microcracks in it, was made of a combined material: the ring base was made of cast iron, and the molding part of the ring had an insert made of steel 40Kh13. This made it possible to increase the temperature on the shape-molding surface, since the thermal conductivity of steel is lower than that of cast iron, and extend the service life of the ring, due to the higher mechanical strength of steel. Furthermore, a radial groove (lock) was made in the metallic insert of the ring, which made it possible to mold the upper edge (collar) of the article without sharp facets, which frequently crumble in the course of molding.

A circular groove 1.5-mm deep was made in the bottom part of the ring adjacent to the insert. The resulting air



**Fig. 4.** Design of matrix for cone molding.

interlayer served as heat insulation, which made it possible to achieve higher temperatures on the molding surface of the ring. A removable electric heater of voltage 36 V was installed on the outer surface of the ring. The heater was used to adjust the ring temperature. The temperatures of the ring and the punch were monitored by thermocouples and were controlled by secondary instruments ATR-1 and ATR-3 installed on the molding press.

The above technical solutions were also used in designing the molding set (the punch and the ring) for cone production. At the same time, the matrix shape is a very significant element in the molding set for cones. In the beginning, cones were molded in a traditional cast iron matrix with a pusher (Fig. 4a). However, with this design of the matrix, melted glass in molding was pressed into the clearance between the pusher and the matrix body. In the cooling stage, the glass inside the clearances cooled, and in the removal phase, the article did not come out of the matrix. A forced removal employing the pusher led to "shooting" of the article and was accompanied by damage to the matrix.

It was decided to abandon the classical mold. The alternative variant proposed a "closed" mold without a pusher and with an insert in the bottom part (Fig. 4b). However, with this design, long vertical notches appeared in the site of the conventional line of the cone from the matrix side. These notches were caused by air remaining on the bottom of the matrix underneath a glass drop. In a subsequent phase of the experiments, the matrix was designed with a false pusher in the bottom part (Fig. 4c), whose main function consisted of releasing air from the matrix in the course of molding.

Thus, an automated line was developed for the production of optical glass elements for kinescopes ranging from 11 to 24 cm in the diagonal, and new mold rigging was developed for making screens and cones 12 cm in the diagonal.